DOCUMENT RESUME

ED 433 685 EF 005 602

| | |
|---|---|
| AUTHOR | Callahan, Michael P.; Parker, Danny S. |
| TITLE | Energy Efficient Florida Educational Facilities: Phase VI. Progress Report: Phase I and II. |
| INSTITUTION | Florida Solar Energy Center, Cape Canaveral. |
| SPONS AGENCY | Florida State Dept. of Education, Tallahassee. Office of Educational Facilities. |
| REPORT NO | FSEC-CR-1063-99 |
| PUB DATE | 1999-02-00 |
| NOTE | 8p. |
| AVAILABLE FROM | Florida Solar Energy Center, 1679 Clearlake Rd., Cocoa, FL 32922-5703. |
| PUB TYPE | Reports - Research (143) |
| EDRS PRICE | MF01/PC01 Plus Postage. |
| DESCRIPTORS | *Climate Control; Comparative Analysis; *Educational Facilities Improvement; *Energy Management; *Lighting; Middle Schools; Public Schools; *Relocatable Facilities |
| IDENTIFIERS | Florida; *Retrofitting |

ABSTRACT

A Florida study examined differences in energy uses in two adjacent portable classrooms to determine if these types of facilities can be made more energy efficient through retrofitting. Retrofitting included an efficient lighting system, new air conditioners, and reflective white metal roofs. Data show the white metal roofing reduced roof, decking, and attic temperatures significantly. The newer air conditioning system (Bard 2.5 ton HVAC unit) had a much higher ventilation rate than the old air conditioning unit and achieved energy savings of approximately 45 percent. The T8 lamp-electronic ballast system that replaced the old T12 system provided energy savings of 20 percent with an average increase in brightness of 4 percent. (Contains 7 references and 6 figures.) (GR)

**********
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
**********

ED 433 685

# Energy Efficient Florida Educational Facilities: Phase VI

*Progress Report -- Phase I and II*

FSEC-CR-1063-99
February 1999

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

Submitted to:

Suzanne Marshall
Florida Department of Education
Office of Educational Facilities
325 W. Gaines St., Rm. 1054
Tallahassee, FL 32399

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY
Mark Yerkes
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
1

Submitted by:

Michael P. Callahan
Danny S. Parker

**Florida Solar Energy Center**
1679 Clearlake Rd.
Cocoa, FL 32922-5703

EF 005 602



BEST COPY AVAILABLE

## Table of Contents


Background ..... 1

Objectives ..... 1

History ..... 1

Introduction ..... 2
- Roof retrofit for portable 035 ..... 2
- Tests on the HVAC of portable 035 ..... 3
- Lighting retrofit: Portable 096 ..... 4

Schedule for Future Retrofits ..... 4

Acknowledgments ..... 4

References ..... 5

**Energy-Efficient Florida Education Facilities: Phase VI**

*Final Survey Analysis*

*Energy-Efficient Portable Classroom Demonstration*

*Presentation of Results to Education Facilities Planners*

Michael P. Callahan and Danny S. Parker

## Background

An ambitious project by the Florida Solar Energy Center (FSEC) and sponsored by the Florida Department of Education (FDOE) is monitoring the energy use of two adjacent portable classrooms to see how they might be made more energy efficient in a hot-humid climate. The classrooms have been monitored for one year to collect data before the energy efficient measures are installed. Retrofit measures include an efficient lighting system, new air conditioners, and reflective white metal roofs.

**Figure 1**. Portable classroom at Silver Sands Middle School

## Objectives

The purpose of this study is to determine if portable classrooms can be made more energy efficient either by retrofit or at the time when new portables are constructed. We also want to determine which measures are the most effective and most affordable so that both energy savings and costs will be tracked. Retrofits include:

- Lighting: current lighting system to be replaced by T8 lamps with electronic ballasts
- Roof: current gray asphalt shingle roof to be replaced with a reflective white metal roof
- Ventilating and Air conditioning: current 3-ton wall mount unit to be replaced with a 2½ ton Bard WH301-A wall mount model

Portable 035 was chosen for the initial retrofits since during the year of collecting baseline data, it's HVAC has performed poorest of the two.

## History

An ever-expanding number of portable classrooms is a fact of life in the Florida school system. Where these relocatable classrooms were once thought to be temporary structures, it is now accepted that they are more or less permanent. One of the main problems of portable classrooms is that they are often poorly received by the community (Rasmussen 1995). They are frequently judged as substandard educational facilities (Florida 1993) and have been called "eyesores" and "monotonous and uninspiring" (Education Facilities Lab 1964). These perceptions have to do mainly with the portables bland coloration and their non-permanent appearance (Rasmussen 1995).

Florida schools, on average, have 9.9 portables with 835 square feet of floor area per portable (Callahan et al. 1997). In addition, studies show that each portable classroom uses approximately 30 kWh/day (Sherwin and Parker 1996) or 10,840 kWh per year (Callahan et al. 1997). Portables account for 11.1% of the energy budget for Florida public schools. Recent research shows that the energy use at Fellsmere Elementary in Central Florida is 360 kWh/day for 12 portables (Sherwin and Parker 1996).

The Florida Solar Energy Center, in conjunction with the Volusia County School Board and the Florida Department of Education, chose Silver Sands Middle School for the study. Silver Sands is located in Port Orange, south of Daytona and has 39 portable classrooms. Portables 035 and 096 were chosen for the study. These portables are side by side and identical in dimensions and configuration. They are 36 ft x 20 ft in an east-west orientation with North and South facing windows. The windows are 4.1 ft x 6.1-6.9 ft with three on both the North and South side of the portables. Total glazed area is 163 $ft^2$ on each side of the portable.

For the project, each building is fully instrumented. Metering equipment consists of thermocouples that measure interior air temperatures and relative humidity, roof surface temperature, attic air temperature, and decking temperature. The portables are also instrumented to measure how long the doors are opened and provided with $CO_2$ sensors to measure its concentration over time. The rooms are also configured to measure total portable kWh, air conditioning (AC) kWh, and lighting kWh. There is also a weather station at the site that measures wind speed, ambient temperature, relative humidity, and solar insolation over a 24 hour period. Instruments are scanned every ten seconds with integrated averages output to logger storage every 15 minutes. All this instrumentation is poled by a Campbell CR10 data logger that is accessed by FSEC at night.

**Introduction**

The project involving energy efficient portable classrooms for Florida has reached several goals since the last update (Callahan and Parker 1998). The previous report commented on retrofits to portable 035 that included the HVAC unit and the lighting systems. Since then, we have retrofit the roof on portable 035, the lighting system on portable 096, and performed additional tests on the Bard WH301-A 2 ½ ton AC unit on portable 035.

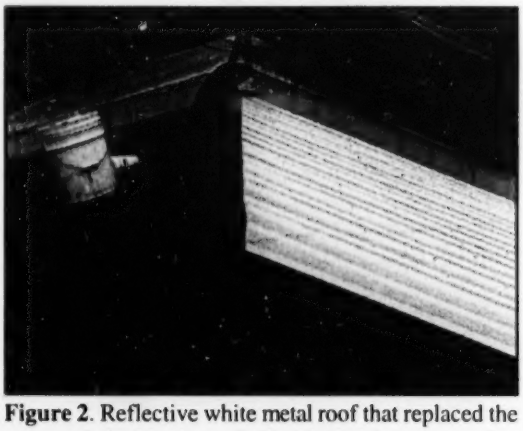

**Figure 2.** Reflective white metal roof that replaced the gray asphalt shingle roof. The black felt is fastened to the decking and then the 5-V crimp panels are fastened.

**Roof retrofit for portable 035**

The old gray asphalt shingle roof on portable 035 was replaced on June 30, 1998 with a reflective white metal roof (Figure 2). The metal roof is 25 gauge 5V- crimp metal panels fastened to the existing decking over a layer of black felt. This retrofit was performed since previous studies have demonstrated lower plenum space temperatures associated with these reflective white roofs as well as significant energy savings (Parker et al. 1995, Parker et al 1996).

The results of this reflective white metal roof were as expected. The roof, decking, and attic temperatures are significantly reduced after the retrofit as seen in Figures 3 and 4. The average roof surface temperature prior to the retrofit (Figure 3) was 101.7° F with the decking and attic air temperatures averaging 101.6°F and 100.7°F, respectively. The maximum temperatures associated with the standard roofing system are very high. The surface, decking and attic air temperature maxima are 160° F, 147° F, and 139° F respectively.

However, after the retrofit (Figure 4) the average and maximum temperatures are much lower. The surface temperature average post retrofit is 88.3° F, the decking temperature is 92.6°F, and the attic air temperature is 92.7° F. The associated temperature maxima are approximately 20-60° F lower than pre-retrofit. This is highly significant and affects occupant comfort and can reduce HVAC power consumption. The graphs are from matched days with similar exterior temperatures.

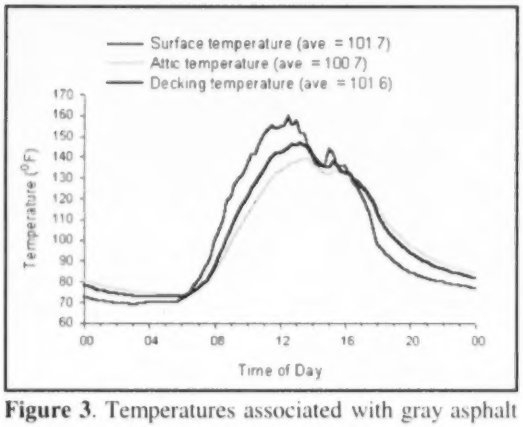


**Figure 3**. Temperatures associated with gray asphalt shingle roof of portable 035 (pre-retrofit)

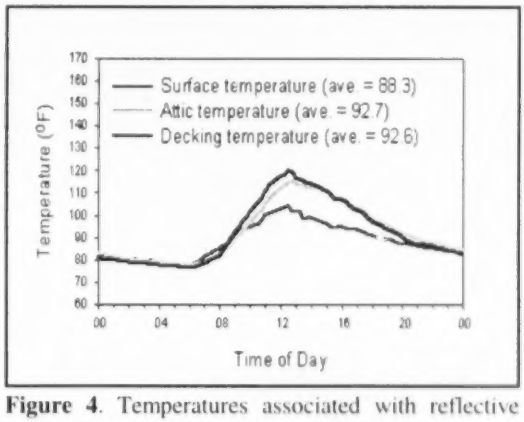


**Figure 4**. Temperatures associated with reflective white metal roof of portable 035 (post retrofit)

**Tests on the HVAC of portable 035**

Tests of the HVAC on portable 035 were completed to determine performance characteristics. The decay of a tracer gas (sodium hexafluoride - $SF_6$) was measured with a Bruel and Kjar model 1302 sampling unit to determine the ventilation rate of the AC unit. The Bard 2 ½ ton HVAC unit has an enthalpy recovery wheel which adds a large volume of outside air which is first cooled and dried by exhaust air prior to being introduced into the classroom.

As a result, the new Bard unit has a much higher ventilation rate than the old AC unit. Portable 096 (with an old AC unit) had a ventilation rate of 0.68 air changes per hour (ACH) while portable 035 (Bard unit) had a ventilation rate of 3.38 ACH, an increase in effective ventilation of almost 500%! This translates to a cfm/person of 15 for portable 035 (which meets the ASHRAE 62-1989 standard) while portable 096 only had a cfm/person of 4.5.

The energy savings associated with the new Bard 2½ ton unit (Figure 5) is approximately 45%. Most of the savings are during unoccupied hours. The data in figure from two matched days with similar occupancy. The large savings are during non-occupied hours and is due, in part, to occupancy sensor control installed on June 4, 1998. Before the retrofit the HVAC was always running. After the retrofit, the system was running only when the room was occupied and was off the rest of the time. This contributes to significant energy reductions.

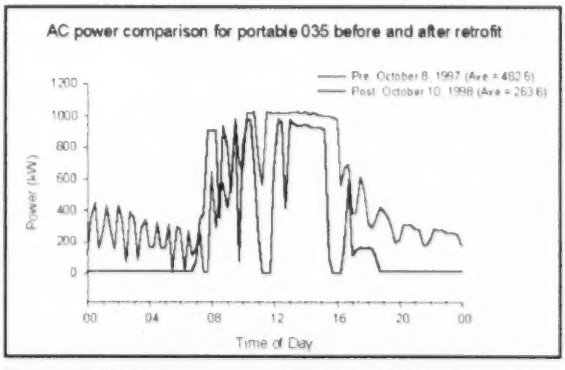
AC power comparison for portable 035 before and after retrofit
Pre: October 8, 1997 (Ave = 482.6)
Post: October 10, 1998 (Ave = 263.6)
Power (kW)
Time of Day

**Figure 5**. HVAC power use for portable 035. Com-parison for matched days pre- and post retrofit.

**Lighting retrofit: Portable 096**

The T12 lamp-magnetic ballast lighting system in place in portable 096 was replaced with a T8 lamp-electronic ballast system on November 23, 1998. The resulting energy savings can be seen in the graph in Figure 6. The data is for two matched days with similar occupancy. The lighting demand is very low for this portable because the teacher in this classroom only uses the middle bank of lights (both pre- and post retrofit).

The new lighting system is indeed more efficient than the old system at a savings of 20%. The T8 lamps also exhibited an increase in average brightness of 4% (pre-retrofit average = 89.9 decalux; post retrofit average = 93.3 decalux).

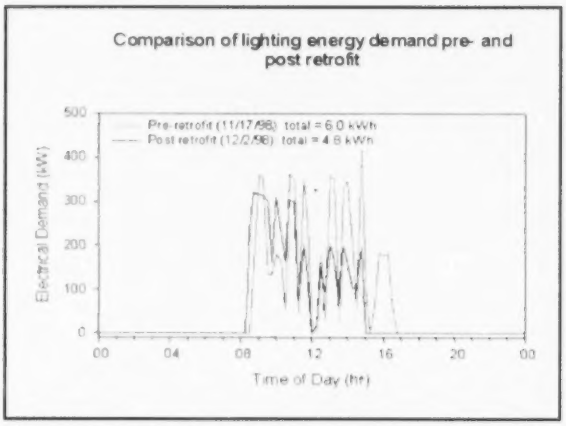


**Figure 6**. Graph of the lighting retrofit on Portable 096. Red is pre-retrofit while blue is post retrofit.

**Schedule for Future Retrofits**

- Improved AC system on portable 096: April, 1999
- White metal roof on portable 096: July, 1999
- Occupancy based control system: October, 1999

**Acknowledgments**

Our appreciation to the Florida Department of Education for their participation with this project. We would like to thank Silver Sands Middle School for their continued enthusiasm concerning this project. Finally, we thank *Manufacturer's Marketing Representative Incorporated* for donating the 2½ ton Bard wall mount unit used on Portable 035 for this project.

**References**

Callahan, M. P., D. S. Parker, W. L. Dutton, and J. E. R. McIlvaine (1997). "Energy Efficiency for Florida Educational Facilities: The 1996 Energy Survey of Florida Schools". FSEC-CR-951-97, Florida Solar Energy Center Cocoa, FL.

Callahan, M. P. and D. S. Parker (1998). "Energy-Efficient Florida Educational Facilities: Improvements to a Portable Classroom at a Volusia County School". FSEC-CR-1008-98, Florida Solar Energy Center, Cocoa, FL.

Educational Facilities Laboratories (1964). Educational School Facilities. New York: Author (ERIC Document Reproduction Service No. ED 066 846).

The Florida Center of Community Design and Research. (1993, November 16). "The use of relocatible classrooms in the public school districts of Florida". (A research report for the Florida Department of Education, Office of Educational Facilities). Tampa: University of South Florida.

Parker, D. S., S. F. Barkaszi, Jr, S. Chandra, D. J. Beal (1995). "Measured Cooling Energy Savings from Reflective Roofing Systems in Florida: Field and Laboratory Research Results". FSEC-PF-293-95, Florida Solar Energy Center, Cocoa, FL.



BEST COPY AVAILABLE

Rasmussen, E., K. Rasmussen, J. Stanard, S. Bernhard, G. Z. Brown, J. Briscoe, J. Kline, P. Kumar, and Z. Wang (1995). "Design and Evaluation of Energy Efficient Modular Classroom Structures". Modern Building Systems, Inc, Aumsville, OR and University of Oregon, Eugene, OR.

Sherwin, J. R. and D. S. Parker (1996). "FLASTAR: Florida Alliance for Saving Taxes and Energy Resources". FSEC-CR-916-96, Florida Solar Energy Center Cocoa, FL.